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CONTENTS

Radio echoes.
Variations in refractive index of dry air.
Thermal expansion of artificial graphite and carbon.
Stresses in enamels.
Tests of red lead paints.
Properties of saturated steam.
Energies of the atomic linkages of the normal paraffin hydrocarbons.
Equilibrium volatility of motor fuels.
Design of compression members in aircraft.

Aging effect in freshly quenched carbon steel.
Rubber cement for mold surfaces.
Corrosion of ferrous metals in acid soils.
Photochemical decomposition of silk.
Simplified practice recommendation for commercial forms reaffirmed.
Simplified practice recommendation covering copper wire nails reaffirmed.
New and revised publications issued during June 1934.

RADIO ECHOES

Special signals are being transmitted from two European radio stations for the study of long-delay echoes. The signals and the whole undertaking are adapted to the participation of persons all over the world who have high-frequency receiving sets, no technical training being required. Long-delay echoes are a most surprising and baffling phenomenon. J. Hals was listening in Norway, one day in 1927, to telegraphic signals from station PCJJ in Holland on a frequency of about 9,600 kc/s. Some of the signals were followed, after about 3 seconds, by a faint echo or reproduction. Echo signals occurring one-seventh of a second after an emitted signal had been well known, being due to the reception of waves that had traveled all the way around the earth. But the discovery of echoes after a materially greater interval than a seventh of a second immediately raised the puzzling question of where such an echo could come from.

The phenomenon has been verified in a few scattered observations by Dutch, British, and French engineers. Echoes have been heard from 1 to 30 seconds after the emitted signal. Not enough is known, however, to deter-

mine what causes the echo signals nor how they are propagated. Two theories have been proposed. One, by Dr. C. Stormer, of Norway, is based on the assumption that there are streams of electrons in space some hundreds of thousands of miles out from the earth's equator, converging in a vast toroid upon the magnetic poles of the earth, and accounting for the aurora borealis or northern lights. Dr. Stormer supposes that the signals are reflected from these electron streams in space. According to the other theory, advanced by Dr. B. Van der Pol and Prof. E. V. Appleton, these echoes are due to a slowing up and reflection of the waves by a peculiar distribution of ionization in the very high levels of the ionosphere (that portion of the atmosphere 65 miles and more above the surface of the earth which is responsible for all long-distance radio transmission).

The British Broadcasting Corporation through its magazine, World-Radio, and with the aid of Professor Appleton, has just inaugurated a worldwide endeavor to learn more about these long-delay echoes. Special emissions are provided from two high-power, high-frequency stations to facilitate observations by anyone who cares to listen with a high-fre-

quency receiving set. Listeners in all parts of the world have been enrolled in the endeavor, over 10,000 of them in Great Britain. It seems likely that information of unique value to science will result, and an orderly explanation of the curious phenomenon developed; when definite data are secured on the frequencies and the times of day and season at which these echoes occur, their intensities, the area over which a given echo is heard, their relation to magnetic storms, sun-spots, etc.

The stations transmitting the special signals are GSB, Daventry, England, and HBL, Geneva, Switzerland (the League of Nations station). The GSB signals are transmitted on 9,510 kc/s, with a tone or modulation of 1,000 cycles per second, each Sunday, Tuesday, and Thursday, from 3:25 to 3:55 a.m., Eastern Standard Time. The HBL signals are transmitted on 6,675 kc/s, unmodulated continuous waves, each Sunday, Wednesday, and Friday, from 6 to 6:30 a.m., Eastern Standard Time. Each transmission consists of a 5-minute adjusting period (GSB using phonographic music, and HBL using its call letters in Morse code repeated) followed by the letters of the alphabet in Morse code, spaced a minute apart. Thus, for instance, GSB transmits the letter A in Morse code at 3:30, and after a minute of silence the letter B at 3:31, then the letter C at 3:32, etc., finishing with the letter Z at 3:55. During the 1-minute intervals between signals the observers listen for echoes and observe the elapsed time in seconds with a watch having a seconds hand. It should be noted that the GSB signals are receivable with a receiving set as used for broadcast programs but the HBL signals are unmodulated CW and therefore require an oscillating receiving set.

Dr. J. H. Dellinger, chief of the radio section of the National Bureau of Standards, would be very glad to have any successful reception of long-delay echoes in the United States reported to him, and will relay the information to the British authorities who are coordinating the investigation for the world as a whole. Observers should give the identifying letter of the signal observed, the time to the nearest second at which the direct signal was heard, the time to the nearest second at which the echo was heard, an estimate of the relative intensities of direct signal and echo, a description of the sharpness or apparent shape of the

echo, and any pertinent information on interference, fading of signals, or other conditions of the observations.

Dr. Dellinger would be interested also in receiving reports on reception of long-delay echoes on any other stations, especially high-frequency stations in the United States. It may, on the other hand, be difficult to be certain of any echoes observed because of the lack of silent periods as in the special signals from the two European stations.

Summaries of the results of this investigation will be made available later in publications in this country. Persons desiring to keep in touch with all details of the project meanwhile can do so by consulting the weekly issues of *World-Radio*, published by Broadcasting House, London, W. 1, England.

VARIATIONS IN REFRACTIVE INDEX OF DRY AIR

It has long been assumed that our knowledge of the earth's atmosphere and its properties is sufficiently complete to justify the making of precise optical measurements in dry air and the subsequent correcting of those results so that they will refer to actual vacuum conditions. A study of possible errors in refractive-index measurement has been made at the Bureau and is described in RP695 in the July number of the *Journal of Research*. One part of the survey included consideration of the effects of small variations in the physical and chemical composition of the atmosphere. Computations based on such variations as seem detectable by chemical methods indicate that the velocity of light in air should be constant to within ± 3 parts in 100 million, but when velocities in air are compared with velocities in vacuum the comparable variations among values reported by various observers over a period of many years are 70 times that amount (or ± 2 parts per million).

At least 40 distinct series of refractive-index observations made since 1857 by almost as many independent observers were considered in arriving at the above quantitative statement. Several different varieties of apparatus have been employed and it is estimated that about one-half of the unexpected variation in the results remains after allowance for inaccuracy and error of various sorts. This remaining variation of ± 1 part per million in the velocity of light in air corresponds to a variation as large as ± 1 part in 300 in the quantity actually de-

terminated, namely, the excess velocity in vacuum over that in air. These data have been examined for evidences of systematic variations and a correlation between refractivity and annual sun-spot number has been found, the Pearson correlation coefficient being -0.48 with a probable error of ± 0.08 .

Degree of storminess of the earth's atmosphere has already been (positively) correlated with yearly relative sun-spot numbers, and thus it seems possible that a decrease in the average rate of stirring and mixing of the air, such as occurs during times of low sun-spot numbers, allows certain denser components (perhaps associated molecules or isotopes) to settle and produce at the earth's surface a gaseous mixture having a slightly higher index of refraction. The data, however, seem to indicate that a 23-year periodicity, corresponding to a magnetic cycle of sun spots, is more favorable than a single sun-spot cycle of 11 years.

If the index of refraction of air varies with changes in solar activity as indicated by this analysis, then some change should be made in the present practice of correcting wave lengths from air to vacuum values. Moreover, all determinations made in standard dry air on the relationships between wave lengths of light and other standards of length would be subject to periodic error having an amplitude of about ± 1 part per million; that is, an error approximately 50 times the accidental errors of the best measurements. More experiments should precede further action on defining an international standard of length in terms of radiation in air.

Meanwhile, it appears unsafe to rely on the constancy of μ , the refractive index of air, over a period of years. The value of 1.0002925 at 0°C and 760 mm pressure is a fair general average for the sodium lines index but it may be preferable to make estimates for any given year from the provisional equation

$$(u_D - 1) \times 10^7 = 2932.2 - 0.15 S,$$

where S is the relative annual sun-spot number.

THERMAL EXPANSION OF ARTIFICIAL GRAPHITE AND CARBON

Artificial graphite.—The linear thermal expansions of longitudinal sections cut from 14-, 3-, 1½-, and 1-inch graphite electrodes and of transverse

sections cut from 14- and 3-inch graphite electrodes, were investigated at various temperatures between 20 and 1,000°C. A comparison of the average expansion curves of the longitudinal and transverse sections is shown in RP693 (fig. 3) in the July number of the Journal of Research, and the ranges of the coefficients of expansion for various temperature ranges are given in table 4 of the same paper. The following conclusions have been reached:

1. The coefficients of expansion of the longitudinal and transverse sections of graphite increase with temperature.
2. The coefficients of expansion of the transverse sections are larger than the coefficients of expansion of the longitudinal sections. For the range from 20 to 1,000°C, the linear expansion of the transverse sections cut from 3-inch graphite is about 110 percent greater than the expansion of the longitudinal sections cut from 3-inch graphite electrodes.
3. There appears to be a tendency for the coefficients of expansion of a longitudinal section to increase with increase in the diameter of the graphite electrode from which the longitudinal section has been cut.
4. The coefficients of expansion of the transverse sections cut from the 3-inch graphite electrodes are larger than the coefficients of expansion of the transverse sections cut from the 14-inch electrodes. For example, for the range from 20 to 1,000°C, the average coefficient of expansion of the transverse sections from the 3-inch graphite is about 40 percent greater than the coefficient of expansion of the transverse sections from the 14-inch graphite electrodes.
5. The difference between the expansion of the transverse and longitudinal sections from the 3-inch graphite electrodes is considerably greater than the difference between the expansion of the transverse and longitudinal sections from the 14-inch electrodes. Figure 3 in the paper indicates that the former difference is about 145 percent greater than the latter difference for the linear expansion between 20 and 1,000°C.
6. The coefficients of expansion of the longitudinal sections cut from the 1-inch graphite electrodes are in good agreement with the data obtained by Day and Sosman on ½-inch graphite electrode.
7. The longitudinal and transverse sections of graphite indicate changes

in length after heating to elevated temperatures and cooling to room temperature. A second heating and cooling cause smaller changes.

8. The differences in expansion and tensile strength between the transverse and longitudinal sections of a graphite electrode may be due to the fact that the electrode in the process of manufacture has been compressed differently in the two directions. Taylor has indicated that during extrusion the outer portions of the electrode are retarded by friction with the walls of the die. There is a tendency toward the formation of a laminated structure in the transverse direction. The aggregate particles and cell walls are more firm and continuous in a lengthwise direction. Voids or pores tend to form with their longer axes lengthwise of the electrode. It seems probable that this has an effect on the expansion in the two directions. Taylor stated that the longitudinal increment is practically a measure of the linear expansion of the material and the transverse change is the linear expansion plus an increment of distortion due to the laminated structure.

9. The grain sizes of the different size electrodes appear to have an effect on expansion.

10. Graphite should be selected with care for the purposes indicated in section I of this paper.

Carbon.—The linear thermal expansions of two types of carbon which are used for the low expanding elements of temperature regulators for domestic gas ovens, were investigated at various temperatures between 20 and 350 C. The coefficients of expansion of carbon made with lampblack are about three times as large as the coefficients of carbon made with petroleum coke.

STRESSES IN ENAMELS

It was announced in Technical News Bulletin No. 195 (July 1933), that a study of the stresses set up in enamel coatings during cooling, after firing on a metal base, was being undertaken. The expansivity of commercial enamels is higher above their critical temperatures, and lower below their critical temperatures, than enameling iron. Hence upon cooling after firing the tendency is first to set up a tensile stress in the enamel as it cools toward its critical temperature, and then to relieve this stress and set up a compressive one on further cooling. The data indicated that the initial tensile stress never grows very large, because it is relieved by yielding of the enamel.

It was possible to relieve virtually all of this tensile stress by a carefully controlled cooling schedule. No further yielding appeared to occur below the critical temperature, and the stresses below this temperature depend upon the net differential contraction of the iron and enamel. Tests have shown that this net differential contraction, and the corresponding stress, can be changed by retarding the rate of cooling of the enamel behind that of the iron, and vice versa. For a given ground coat enamel, normally in compression at room temperature, the stress is increased by an increase in the time or temperature of firing.

TESTS OF RED-LEAD PAINTS

Five and one-half years ago a large number of steel panels painted with two coats of red-lead paints were exposed on the roof of the chemistry building at 45° facing south. The formulas consisted of 20, 22, 25, 28, 30, 33, 35, and 40 pounds of red lead (95 percent grade) to 1 gallon of boiled linseed oil (no thinner or drier added). Thus far the paints have failed exactly in order of increasing amount of red lead, the first one to fail being the paint composed of 20 pounds of red lead to 1 gallon of oil. At this time (5½ years exposure), the paint composed of 28 pounds of red lead to 1 gallon of oil has failed (rusting). The 30-, 33-, 35-, and 40-pound paints are still in good condition.

PROPERTIES OF SATURATED STEAM

The remarkable development of the steam engine, which reached its height in the early part of the present century, owed much to the so-called "steam tables" or tables setting forth the properties of steam at various temperatures and pressures. These tables were based largely upon the experimental work of Regnault, which was carried out about 80 years ago. There were hardly any serious attempts to improve upon Regnault's work for some 50 or 60 years, but with the development of the steam turbine, higher temperatures and pressures were introduced, and the existing data were no longer adequate, either as to accuracy or range of temperature and pressure.

In the early 1900's, a considerable amount of work on the properties of steam was done in Germany and England, and a little elsewhere, but it was not until 1921 that a few members of the American Society of Mechani-

cal Engineers, realizing that practice had gone far beyond research, initiated a movement to conduct a series of systematic investigations of the properties of saturated and superheated steam.

The experimental work was assigned to Harvard University, under the direction of Dr. H. N. Davis; to Massachusetts Institute of Technology, under the direction of Dr. F. G. Keyes; and to the National Bureau of Standards, under the direction of Dr. N. S. Osborne. Later, arrangements were made to coordinate the work with that going on in European laboratories, and as a result two international steam conferences have been held, one in London in 1929, a second in Berlin in 1931, and arrangements are being made to hold the third in Boston, New York, and Washington during September of this year.

In the division of the work among the American laboratories, the part assigned to the Bureau was chiefly the calorimetric measurements, and was to cover both saturated and superheated steam. Work was begun actively some 10 years ago, and the work on saturated steam is just being brought to a successful conclusion. Two calorimeters, one for the lower range of temperatures and pressures, the second for the higher range, were designed, constructed, and used in an extensive series of measurements, which extended from 0 to 373 C. (32 to 704 F.) and up to a pressure of 3,200 lb/in². In other words, the measurements extend to the limit of the range in which saturated steam can exist. In the course of the work it was found expedient to make other measurements, which, combined with the calorimetric data, will make it possible for the Bureau to present, at the forthcoming international conference, data on all the properties of water and saturated steam, needed for the preparation of a complete table.

The work has been generously supported by the steam-using industries, and a large part of the cost has been met by them. The funds were handled and the work supervised by the special research committee on thermal properties of steam, organized by the American Society of Mechanical Engineers.

With the completion of the work on saturated steam, the staff is well prepared and much of the required equipment is available, to undertake the difficult task of investigating the properties of superheated steam. It is not yet clear just how the necessary funds

for this work can be obtained, but with the very successful outcome of the first part of the work, it is hoped that means will be found for its continuance, in order that knowledge of the properties of superheated steam may become as complete and accurate as our present knowledge of saturated steam.

ENERGIES OF THE ATOMIC LINKAGES OF THE NORMAL PARAFFIN HYDROCARBONS

As described in Technical News Bulletin No. 206 (June 1934), the thermochemical laboratory of the Bureau has completed the calorimetric determination of the heats of combustion of ethane, propane, normal butane, and normal pentane. These data, combined with those obtained for methane in the same laboratory several years ago, give accurate values for the heats of combustion of the first five members of the series of normal paraffin hydrocarbons in the gaseous state.

With these new data, accurate values have been deducted for the heats of combustion in the gaseous state of all the normal paraffin hydrocarbons containing more than 5 carbon atoms. The values for the heats of combustion of normal C_nH_{2n+2} are found to be linear with n , the number of carbon atoms, above, but not linear below, $n=6$. Up to the present time the heats of combustion of the paraffin hydrocarbons have been supposed to vary linearly with the number of carbon atoms from methane on.

The following generalization is made concerning the heats of combustion of gaseous organic molecules containing alkyl groups: In any organic molecule containing a normal alkyl group of more than 5 carbon atoms, the addition of a CH_3 group to the normal alkyl group to form the next higher normal alkyl group results in an increase in the heat of combustion of the organic molecule in the gaseous state, at 25 C and a constant total pressure of 1 atmosphere, of 157.00 ± 0.08 k-cals per mole.

The new data can also be used to determine how the energy of dissociation of the normal paraffin molecule, C_nH_{2n+2} , into gaseous carbon and hydrogen atoms, which is a quantity possessing considerable importance in determining the thermodynamic stability of the molecule, varies with the number of carbon atoms in the molecule. The energy of dissociation at 0° K of gaseous normal C_nH_{2n+2} into

gaseous carbon and hydrogen atoms is found to be a linear function of n above, but not linear below, $n=6$. The deviations from linearity for the latter are in the direction of greater stability of the molecule, and have the following values: Methane, 4.81 ± 0.08 ; ethane, 1.59 ± 0.14 ; propane, 0.83 ± 0.19 ; normal butane, 0.46 ± 0.27 ; normal pentane, 0.13 ± 0.37 , k-cal per mole. These deviations can be explained by distinguishing different kinds of C-H and of C-C linkages in the normal paraffin molecules.

EQUILIBRIUM VOLATILITY OF MOTOR FUELS

Fuel volatility is an important factor in working out the relationship between fuel characteristics and engine performance. For many years the Bureau has studied fuel volatility, in cooperation with the automotive and petroleum industries, and the experimental data obtained and the conclusions reached are set forth in RP694 in the July number of the Journal of Research. An apparatus and method are described for the measurement of the equilibrium volatility of motor fuels, and experimental data are presented on 38 gasolines and blends covering a wide range of volatility. A correlation is shown to exist between equilibrium volatility data and distillation data obtained by the standard American Society for Testing Materials method. By use of the equations deduced, it is possible to obtain from distillation data all of the equilibrium volatility data of interest in connection with engine performance. In a later paper, the results of the present investigation will be applied to the prediction of a number of the performance characteristics of fuels in service.

DESIGN OF COMPRESSION MEMBERS IN AIRCRAFT

The resistance of frameworks to buckling has been investigated for some time, notably by Friedrich Bleich. Solutions of the so-called four-moment equation are largely involved, and most solutions apply to very restricted frameworks. A slightly more general case is discussed in RP698 in the Journal of Research for July.

AGING EFFECT IN FRESHLY QUENCHED CARBON STEEL

By the use of thermo-magnetic analysis, a study has been completed recently on the effect of prolonged

aging at room temperature and at the boiling point of water (100°C) of freshly hardened steel. After quenching specimens in water from 825°C, comparisons were made between specimens as quenched and after being treated as follows:

1. Aged for 2 years at room temperature of 20°C (68°F).
2. Tempered at 100°C (212°F) for 2 months.
3. Tempered at 100°C, 2 months, and aged at room temperature for 2 years.
4. Cooled in liquid air.
5. Cooled in liquid air, tempered at 100°C for 2 months.

Changes in magnetization of the materials while heated to, and held at 200, 235, and 300°C (390, 455, and 570°F) showed that there was a pronounced difference in the changes in magnetization at these temperatures for the different previous thermal treatments, and that tempering at 100°C and long-time aging of quenched steel had definite effects on the rate of the decomposition of martensite, the hard constituent of the quenched steel.

These effects were much more definitely shown by the thermo-magnetic analyses than by hardness tests and microscopic examination. The results are considered to be evidence that significant changes in the properties of hardened carbon steel edged tools, such as razors and surgical instruments, may perhaps result from heating them in steam or boiling water.

RUBBER CEMENT FOR MOLD SURFACES

During the month two large bronze plaques to be used at the entrance to the Bureau's grounds were cast in the experimental foundry. These plaques carry the Department of Commerce seal and the inscription, "National Bureau of Standards", in raised letters on a matte background. With regular foundry technique the results were not entirely satisfactory because of slight washing of the sand and other causes. The difficulty was overcome by spraying the mold surfaces with rubber cement, which caused the fine surface particles to adhere together firmly and assured the accurate reproduction of the details of the plaque. Also, this procedure permitted the casting of the metal in a green-sand mold. Economy in handling of the molds as well as in producing castings of a very excellent quality is obtained by the use of rubber cement surfacing. The use of rubber cement as a binder for foundry cores is de-

scribed in NBS Circular No. 530.

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scribed in the Bureau's Letter Circular No. 252, which may be obtained without charge upon application to the Bureau.

CORROSION OF FERROUS METALS IN ACID SOILS

Local areas of corrosive soils containing accumulations of salts or other corrosive materials have been successfully located by appropriate methods, but little progress has been made in identifying corrosive areas in which salts or other soluble materials are present in very small concentrations, if at all. A characteristic feature of the soils of the eastern half of the United States as a class is their low concentration of soluble material. In order to identify corrosive soils low in soluble material and to account for their corrosiveness, it is necessary, therefore, to employ methods based on some characteristic of the soil other than its salt content.

Since the removal of the soluble material in soils by rainfall is generally accompanied by the development of an acid reaction in the soil, it was reasonable to assume that the acidity of soils might be an important factor in their corrosiveness. The fact that a large number of the soils in which the Bureau's test sites are located show various degrees of acidity made it possible to investigate the importance of this factor in soil corrosion.

By comparing the average rates of pitting of ferrous specimens which have been buried for 8 and 10 years with values for the total acidity of the soils at the test sites, it was found that a definite relation exists between acidity and pitting. A similar relation was also obtained between the losses of weight of specimens in a short time laboratory test and the total acidity of the soils.

The effect of soil acidity in inducing corrosiveness was attributed to its action in preventing the formation of protective layers of ferrous and ferric hydroxides on the metal surface. In neutral and slightly alkaline soils the hydroxide film tends to reduce the accessibility of oxygen at the cathode surface, thereby reducing the rate of corrosion.

The effect on corrosion of the physical characteristics of soils which determine their permeability to air was studied by comparing data that measured permeability with an expression for the ratio of uncorroded to corroded

area. The correlations obtained indicate that, assuming other factors to remain the same, the greater the permeability of the soils, (exclusive of sands), the greater is the tendency for pitting.

For a more complete account of this work the July number of the Journal of Research (RP696) should be consulted.

PHOTOCHEMICAL DECOMPOSITION OF SILK

In some previous work the susceptibility of silk cloth to deterioration during exposure to light was studied, employing an accelerated aging test. This was obtained by exposure to the light of a glass-enclosed carbon arc lamp. It was shown that the extent to which the silk is weakened depends upon its "pH" (as defined by its extract). The maximum stability was found to be at about pH 10. As the pH was increased above pH 11 and decreased below pH 3, the stability of the silk decreased rapidly. The purpose of an investigation described in RP697 in the July number of the Journal of Research was to study the deterioration of silk on exposure to daylight under natural conditions of use. Both the chemical and physical breakdowns were followed. The experiments were designed to show something of the nature of the photochemical reaction.

The strength of silk cloth decreased and its ammonia nitrogen content increased on exposure to sunlight. Samples of the cloth treated with a tenth normal solution of sodium hydroxide showed smaller changes and samples treated with a tenth normal solution of sulphuric acid greater changes, than the untreated cloth under the same conditions.

Similar results were obtained on exposure of samples to north skylight. Samples treated with sodium carbonate solution of 1 percent or less in concentration showed the greatest stability.

The amino nitrogen content was the same for silk stored in the dark and silk exposed to sunlight for 3 months. The rate of hydrolysis in 0.5 normal sodium hydroxide solution, measured by the formation of amino nitrogen, was the same for both samples.

The decrease in breaking strength and increase in ammonia nitrogen content of silk on exposure to light are brought about by atmospheric oxidation in the presence of light.

The results of these experiments are in accord with those obtained in the accelerated aging tests of silk, using the carbon arc lamp as a light source.

SIMPLIFIED PRACTICE RECOMMENDATION FOR COMMERCIAL FORMS REAFFIRMED

Simplified Practice Recommendation R37-28, covering invoice, purchase order, and inquiry forms has been reaffirmed, without change, by the standing committee in charge of the periodic review of the program.

In 1919 the first efforts were made to develop a standard invoice and largely through the activities of the Railway Accounting Officers Association, the National Association of Purchasing Agents, the National Association of Cost Accountants, and Division VI, Purchases and Stores, American Railway Association, an invoice evolved in 1925, became known as the "Simplified Invoice Form", and which attained wide-spread use.

The simplified invoice form was revised in 1927, and since that time it has received increased support by a great many business concerns, and by trade associations with an aggregate membership of approximately 110,000.

Copies of Simplified Practice Recommendation R37-28 may be obtained from the Superintendent of Documents, United States Government Printing Office, Washington, D.C., for 5 cents each. A facsimile of the simplified invoice form may be secured by writing to the chief of the division of simplified practice, National Bureau of Standards, Washington, D.C.

SIMPLIFIED PRACTICE RECOMMENDATION COVERING COPPER WIRE NAILS REAFFIRMED

Simplified Practice Recommendation R150, covering copper wire nails, has been reaffirmed, without change, as of July 1, 1934. This recommendation, which was proposed and developed by the industry, and which concerns the length and gage of common copper wire nails with flat heads, and copper wire slating nails, first became effective on December 1, 1933. It will be available in printed form in the near future and will bear the index number R150-34. This recommendation represents a substantial reduction in the variety previously listed for regular stock purposes.

NEW AND REVISED PUBLICATIONS ISSUED DURING JUNE 1934

Journal of Research¹

Bureau of Standards Journal of Research, vol. 12, no. 6, June 1934 (RP nos. 685 to 690, inclusive, with index to volume 12). Price 25 cents. Obtainable by subscription.

Research Papers¹

[Reprints from the April, May, and July 1934 Journal of Research]

NOTICE.—Beginning with the July 1934 issue of this Journal the prices of the separate Research Papers appearing in each issue will be given in the table of contents.

This new arrangement provides a prompt and convenient method whereby readers desiring copies of separate Research Papers appearing therein may send their orders immediately to the Superintendent of Documents, United States Government Printing Office, Washington, D.C., and will aid him in determining the number of copies to be printed. The type is not held and there is but one edition.

RP666. Standard absorption curves for specifying the quality of X-radiation; L. S. Taylor and G. Singer. Price 5 cents.

RP667. Thermal expansions of some soda-lime-silica glasses as functions of the composition; B. C. Schmid, A. N. Finn, and J. C. Young. Price 5 cents.

RP668. Apparatus for measuring thermal conductivity of metals up to 600 C; M. S. Van Dusen and S. M. Shelton. Price 5 cents.

RP669. Thermal conductivity of some irons and steels over the temperature range 100 to 500 C; S. M. Shelton. Price 5 cents.

RP670. Comparative performance of watches with elinvar and with steel hairsprings; R. E. Gould. Price 5 cents.

¹ Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D.C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, \$2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and Republic of Panama); other countries, 70 cents and \$3.25, respectively.

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RP671. First spectrum of tantalum; C. C. Kiess and E. Z. Stowell. Price 5 cents.

RP672. Some optical and crystallographical properties of the alkali zinc uranyl acetates; H. Insley and F. W. Glaze. Price 5 cents.

RP673. The carbonization process: A study of the system wool-sulphuric acid-water; M. Harris. Price 5 cents.

RP674. Compression cutting test for rubber; W. L. Holt. Price 5 cents.

RP675. Wear of dies for extruding plastic clay; R. T. Stull. Price 5 cents.

RP676. Freezing point of rhodium; W. F. Roesser and H. T. Wensel. Price 5 cents.

RP677. Establishment of a scale of color temperature; H. T. Wensel, D. B. Judd, and W. F. Roesser. Price 5 cents.

RP678. A propeller-vibration indicator; H. L. Dryden and L. B. Tucker. Price 5 cents.

RP679. Hosiery Testing machine; H. F. Schleifer and W. D. Appel. Price 5 cents.

RP681. A sensitive instrument for measuring the air permeability of paper and other sheet materials; F. T. Carson. Price 5 cents.

RP682. Effect of experimental conditions on the measurement of air permeability of paper; F. T. Carson. Price 5 cents.

RP683. A study of the properties of mortars and bricks and their relation to bond; L. A. Palmer and D. A. Parsons. Price 5 cents.

RP684. Heat of hydration of portland cement pastes; W. Lerch and R. H. Bogue. Price 5 cents.

RP691. A formula and tables for the pressure of saturated water vapor in the range 0 to 374 C; N. S. Osborne and C. H. Myers. Price 5 cents.

Miscellaneous Publications¹

M144. Summary report of Bureau of Standards research on preservation of records; A. E. Kimberly and B. W. Scribner. Price 5 cents.

¹ Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D.C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, \$2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and Republic of Panama); other countries, 70 cents and \$3.25, respectively.

Technical News Bulletin¹

Technical News Bulletin no. 206, June 1934. Price 5 cents. Obtainable by subscription.

Letter Circulars

It is the intent of the Bureau to distribute single copies of these letter circulars on request only to those parties having special interest in the individual letter circular. Economy necessitates limitation in the number of copies issued. It is not the intent to supply parties with a copy of each letter circular issued during the month. Letter circulars are necessarily of a temporary nature designed to answer numerous inquiries on a given subject. Requests should be addressed to the National Bureau of Standards.

LC416. List of publications of interest to household purchasers.

LC417. Publications on thermal expansion.

LC419. Information on refrigeration.

Outside Publications²

Paffenbarger, George C., and Sweeney, W. T., Specifications and certifications for dental materials, Journal of the American Dental Association (212 East Superior St., Chicago, Ill.), 21, 658 (April 1934).

Brown, C. R., The determination of the ignition temperature of solid materials, Dissertation submitted for degree of Doctor of Science, Catholic University of America (Washington, D.C.), June 1934.

Jackson, R. F., A critical study of the Munson-Walker method for reducing sugars, Journal of the Association of Official Agricultural Chemists (Box no. 290, Pennsylvania Ave. Station, Washington, D.C.), 17, 293 (May 1934).

McBurney, J. W., Indentation of asphalt tile, Preprint of paper presented at 37th annual meeting,

¹ Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D.C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, \$2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and Republic of Panama); other countries, 70 cents and \$3.25, respectively.

² These publications are not for sale by the Government. Requests should be sent direct to publishers.

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